PAPERS AND ORIGINALS

Association between gas cooking and respiratory disease in children

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Summary

A four-year longitudinal study of the prevalence of respiratory symptoms and disease in schoolchildren and related environmental and socio-economic factors is in progress. We report results for the first year of this study (1973).

A total of 5758 children aged 6 to 11 years from 28 randomly selected areas of England and Scotland were examined. In an analysis of the effects on health of possible indoor pollutants, boys and girls from homes in which gas was used for cooking were found to have more cough, "colds going to the chest", and bronchitis than children from homes where electricity was used. The girls also had more wheeze if their families used gas for cooking. This "cooking effect" appeared to be independent of the effects of age, social class, latitude, population density, family size, overcrowding, outdoor levels of smoke and sulphur dioxide and types of fuel used for heating. It was concluded that elevated levels of oxides of nitrogen arising from the combustion of gas might be the cause of the increased respiratory illness.

Introduction

Respiratory disease is a major cause of childhood morbidity. Episodes of respiratory disease have been said to predispose children to acute respiratory disease in early adulthood,[1] which may in turn predispose them to later chronic respiratory disease[2]—a major cause of morbidity and mortality among older people in the United Kingdom.[3, 4] The burden of chronic respiratory disease might be reduced if environmental hazards known to be associated with acute respiratory disease in childhood were altered or removed.

Outdoor air pollution has been repeatedly shown to be related to the prevalence of respiratory illness in children[5, 6] and our data have suggested that the relationship may exist even at relatively low levels of pollution.[7] We examine here the relation between respiratory illness and indoor air pollution arising from cooking fuels. The two fuels predominantly used in the home for cooking are electricity and gas. The former causes negligible pollution, but the latter gives rise to a range of pollutants on combustion.

Methods

This project was part of a larger study of the health and growth of primary schoolchildren which started in 1972. Twenty-two employment exchange areas in England and six in Scotland were selected from a total of 547 areas by stratified random sampling so that poorer areas were proportionately better represented. Details of the sampling method have been published elsewhere.[8]

The study population consisted of all children aged 6 to 11 in selected primary schools within each of the 28 areas who were followed up in 1973. During this year questions on respiratory illness and the type of fuel used for cooking in the home were added to the questionnaire. Out of 9128 white children seen in 1972 7851 were re-examined in 1973 [illegible].

Information about respiratory symptoms experienced during the previous 12 months and episodes of bronchitis and asthma was requested in a self-administered questionnaire completed by the children's parents or guardians.[7] The question about the cooking fuel used at home was: Do you cook by electricity, gas, coal, other (if other, please specify)? There was a similar question for the main fuel used for heating and other questions to elicit socioeconomic information. The children were classified according to their fathers' occupations into the six social class groups defined by the Registrar General.[9] No questions were asked about parental smoking habits.

Outdoor smoke and sulphur dioxide (SO_2) were sampled over 24-hour periods at or near the study schools in 10 of the areas, using the daily smoke SO_2 sampler.[10]

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Of the 7851 children 214 were excluded from the analysis because they came from homes in which coal or a mixture of fuels was used for cooking. There was no information on cooking fuels for 890 of the remaining 7637 children, which left 6747 children who came from homes in which either electricity or gas only was used for cooking. Data (on age, sex, social class and responses to all six questions on respiratory symptoms and diseases) were complete for 5758 of these children: 3204 lived in houses where electricity was used for cooking and 2554 in homes where gas was used.

Results and comment

SIMPLE PREVALENCES

In each case the prevalence of each respiratory symptom and disease was higher in boys and girls from homes where gas was used (table I). The differences in prevalence between the two groups of children were significant ($P < 0.05$) for bronchitis, day or night cough, and colds going to the chest in both sexes and, in girls, for all other symptoms. Prevalence rates were higher in boys than in girls.

COMPARISONS OF RESPIRATORY ILLNESS ALLOWING FOR RELATED FACTORS

The prevalence of symptoms and diseases in the children was greater in the lower than in the upper social classes and declined with age. Since the proportion of children in social classes I, II, and III (non-manual) was higher among those from homes where electricity was used for cooking (table II) and there were minor differences in age between the two groups of children, it was important to allow for the effect of these factors in the analyses. Moreover, the analysis shown in table I did not take into account the fact that some children had more than one symptom or disease. Fortunately a new computer package—GLIM (Generalised Linear Interactive Models)—which has a facility for fitting log-linear models[11] to frequency data has become available. These models are particularly suitable for analysing the relation between a set of factors and a categorical response when the response cannot be sensibly represented on a quantitative scale. This is a considerable advantage over more commonly used methods, which require the construction of a score, with associated assumptions of normality and the necessity for intervals on the scale to have some quantitative interpretation.

To carry out this analysis we prepared a set of response categories using histories of bronchitis, colds going to the chest, and the three symptoms (day and night cough, morning cough and wheeze). Children reported to have asthma were excluded from the analysis. Although the analysis technique did not require it, we used a sequence of categories related to increasing severity of respiratory illness to simplify the interpretation. Because there was no obviously correct way of doing this we chose the simplest. A count of the positive responses to the five questions on symptoms and diseases was used to define the following four categories: (1) no symptom or disease; (2) one symptom or disease; (3) two symptoms or diseases; (4) three or more symptoms or diseases.

Since the prevalence of symptoms and disease differed between the sexes, boys and girls were analysed separately. Within each sex the children were divided into eight subgroups, according to social class (III (*non-manual*) or above; or class III (*manual*) or below); age (below 8 years; or 8 years and over); and the type of cooking fuel used. Within each subgroup the distribution of the children among the four categories of respiratory illness was determined (table III). These distributions for all the subgroups were then analysed using the log-linear model facility in the general linear model-fitting program[12] to test whether there were systematic and consistent differences between them related to social class, age, or types of fuel. This technique had obvious advantages over the relative-risk approach, with its requirement that the response categories be compressed into a dichotomy, with a consequent loss of information.

As expected, the analyses for both sexes showed that the proportion in the more severe categories of respiratory illness was greater in the lower social class group than the higher group ($P < 0.03$) and greater for younger than for older children ($P < 0.01$). An association between greater severity of illness and the use of gas for cooking was also found after allowing for the effects of social class and age ($P < 0.07$ for boys; $P < 0.001$ for girls). In other words, in the gas cooking groups the proportion of children in the more severe illness categories increased at the expense of those in the less severe categories. Thus if girls aged under 8 years and from social class III (*manual*) or below are taken as an example, 11% of those from homes using electricity had two or more diseases or symptoms compared with 16% of those from homes using gas.

Effects due to latitude and the degree of urbanisation might also have biased the results, so the analysis was extended to include these factors. To represent latitude the areas were grouped into three regions: Scotland, England north of the line joining the Bristol Channel to the Wash, and England south of this line. Urban and rural areas were defined according to whether they had a population density above or below 20 people/hectare. As this extended analysis was too large for our computer facility, urban and rural areas were analysed separately and the respiratory illness categories 3 and 4 combined into one. This also helped to ensure adequate numbers in each category within the 40 subgroups.

Allowing for the effect of these factors in the analysis made no difference to the direction of the relationships of illness severity with age and social class, although the associations did not always reach statistical significance. A relation with latitude did emerge, but this seemed to depend on the degree of urbanisation. For rural areas there was some evidence, confined to girls, that there was more illness in southern England. For urban areas, on the other hand, the proportion of children in the more severe categories was highest in northern England and lowest in the south ($P < 0.001$ for boys; and $P < 0.005$ for girls). This finding is difficult to explain simply, although it could be argued that latitude has no effect in rural areas—that is the significant result for the girls was a chance one, while in the urban areas the

TABLE I—*Prevalence (%) of respiratory symptoms and diseases during last 12 months in boys and girls according to type of fuel used for cooking in the home*

Symptoms and diseases	Boys			Girls		
	Electricity	Gas	P*	Electricity	Gas	P*
Bronchitis	3·1	5·7	<0·001	2·0	4·7	<0·001
Day or night cough	5·8	8·5	<0·001	3·4	8·7	<0·001
Morning cough	3·0	4·3	<0·05	2·0	4·1	<0·001
Colds going to chest	23·0	26·4	<0·005	19·8	24·1	<0·005
Wheeze	10·3	11·2	≈0·5	9·7	11·6	<0·005
Asthma	1·8	2·7	≈0·2	1·0	1·6	≈0·2
No of children	3049	3274		3556	3240	

*Probability value for difference between prevalence rates, χ^2 test.

TABLE II—*Distribution of social class in each cooking group*

Social class:	I	II	III (non-manual)	III (manual)	IV	V	Total
No (%) in electricity group	151 (4·7)	976 (18·0)	333 (10·4)	1604 (50·2)	436 (13·6)	100 (3·1)	3204 (100)
No (%) in gas group	83 (3·2)	319 (12·5)	192 (7·5)	1373 (53·8)	406 (15·9)	181 (7·1)	2554 (100)
No (%) of children (total)	234 (4·1)	895 (15·5)	525 (9·1)	2941 (51·0)	842 (14·6)	281 (4·9)	5758 (100)

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TABLE III—*Percentage of boys and girls classified by respiratory illness category, social class, age, and type of fuel used for cooking in the home*

Respiratory illness category*	Social classes I-III (non-manual)				Social classes III (manual)-V			
	<5 years		≥5 years		<5 years		≥5 years	
	Electricity	Gas	Electricity	Gas	Electricity	Gas	Electricity	Gas
				Boys				
1	74·4	71·9	79·2	79·7	70·1	62·5	75·0	71·0
2	15·6	14·6	13·1	15·9	17·6	21·3	15·7	17·7
3	5·9	9·0	5·2	3·2	9·9	9·4	5·5	6·3
4	3·6	2·5	2·5	1·2	2·4	7·0	3·8	5·0
Total†	100 (203)	100 (80)	100 (305)	100 (189)	100 (375)	100 (304)	100 (675)	100 (454)
				Girls				
1	77·6	69·6	81·9	80·6	65·2	66·5	82·2	72·2
2	15·6	17·6	14·2	14·4	23·1	17·5	12·3	18·2
3	4·1	8·9	2·6	3·7	7·4	8·8	3·7	6·9
4	2·7	3·9	1·3	1·1	3·3	7·2	1·8	2·7
Total†	100 (171)	100 (112)	100 (301)	100 (167)	100 (391)	100 (337)	100 (674)	100 (623)

*See text. †Numbers of children are given in parentheses, but they do not add up to 5758 as estimates have been excluded.

effects followed the pattern one might have expected given the more intense industrialisation of the north.

The association between the distribution among the respiratory illness categories and the type of cooking fuel was still apparent even after these extra factors were taken into account. The proportion of children with more than one disease or symptom was still higher among those from homes where gas was used for cooking. But this association was significant only for girls in urban areas ($P = 0.03$); though the trend was in the same direction for both sexes in urban and rural areas. In fact for the girls in rural areas and the boys in urban areas the association was not far from significance ($P = 0.10$).

Although we allowed for the effects of latitude and degree of urbanisation by classifying the areas into six groups it was still possible that some of the cooking effect could have been explained by the differences between the areas within each group. As it was impractical to divide the children into still more sub-groups we expanded the area groups to 26 at the expense of the respiratory illness categories, which were reduced to two (those with and those without symptoms or diseases). Using a logistic transformation of the proportion of children in the illness categories as the outcome variable, we obtained very similar results to our first log-linear model analysis. After allowing for the effects of social class, age, and area there was a significant association of symptoms and diseases with the use of gas for cooking in girls ($P = 0.05$), and, although the effect did not reach significance in boys ($P = 0.30$), it was in the same direction.

We also considered other factors that might have affected the comparisons, such as the number of siblings, overcrowding in the home, fuels used for heating and atmospheric smoke and SO_2 levels. Data for these variables were, however, missing for many of the children, so only very small numbers remained within the necessary subgroups. Thus the results from these analyses were not so conclusive and will need confirmation by study of the more complete data now being collected. None the less, when these factors were taken into account, the proportion of children with one or more respiratory symptoms or diseases remained higher in both boys and girls from homes where gas was used. This approached significance in girls ($P \simeq 0.10$), but not in boys.

Discussion

We have shown that children from homes where gas is used for cooking have a higher prevalence of respiratory symptoms and disease. This may be due to pollution of the indoor atmosphere by the products of gas combustion, but other factors associated with gas cooking and respiratory disease may still underlie the findings. So far as possible we have made allowances for most of the obvious factors. Although the grouping of social class which we had to use was rather broad, the differences in the use of electricity and gas between the social class groups were quite small (table II). On the other hand, we could not include family smoking habits in the analysis, but the known relation between smoking and social class[12] has allowed us to avoid at least some of the potential bias from this source. It seems unlikely that within our social class groups there was a higher prevalence of smoking in homes where gas was used for cooking.

The main constituents in the emissions from a gas cooker are N_2, O_2, CO_2, and water vapour, with small amounts of CH_4, C_2H_4, and other hydrocarbons, CO, NO, NO_2, and various aldehydes. Other pollutants, such as HF, HCl, and HBr, can be formed as a result of residual aerosol spray vapours in combustion air passing through the flame on the cooker.

Reports[13-15] indicate that the concentrations of oxides of nitrogen emitted from gas cookers are above those recommended in the US Primary Air Quality Standards[16] and Emergency Episode Criteria Guidelines.[17] The maximum level recommended for the annual arithmetic mean is 0·05 ppm, and the alert levels for the 24-hour and one-hour averages are 0·15 ppm and 0·6 ppm respectively. Derwent and Stewart[14] have reported that the concentrations of oxides of nitrogen taken as a whole that are emitted from a gas cooker range from 8 to 33 ppm. Wade *et al*[15] found that over a two-week period the average concentration of NO_2 in kitchens where a gas cooker was used was over 0·05 ppm, the maximum recommended ambient level. They also showed how the concentration in different parts of the home fluctuated with the use of the cooker, and reached average levels of over 0·15 ppm for two hours in the kitchen.

Little has been published about the effects of these gases on human health. Reports of human exposure have been confined to agricultural and industrial accidents, in which adults have been suddenly exposed to very high levels of NO and NO_2, with resulting extensive pulmonary oedema. These levels were much higher than those emitted by gas cookers.[18-19]

Information on the effects on health of low-level exposure to NO and NO_2 has come from animal and epidemiological studies. Mice have been shown to have an increased susceptibility to infection by *Klebsiella pneumoniae* when first exposed to concentrations of NO_2 of 3·4 to 25 ppm[20] for about two hours. Shy *et al*, reporting some of the Community Health and Environmental Surveillance System studies,[21] attributed a modest decrease in the respiratory function of children aged 7–8 to exposure to a yearly average concentration of outdoor NO_2 of 0·08 ppm. Their measurements of NO_2 have since, however, been shown to be highly correlated with SO_2 concentrations, and the effects of the two pollutants could not be separated.[22] We have found only one report of studies similar to ours, which were carried out in families living in a suburb of Columbus, Ohio, and on Long Island, New York.[23] In contrast to our findings, the authors found no association between respiratory disease and the use of electricity or gas for cooking.

SO_2 is also given off during the burning of gas and is potentially harmful to health. But the sulphur content of gas is legally limited and the levels of SO_2 produced are likely to be very much

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lower than those currently believed to have adverse effects on health. Thus it seems unlikely that this pollutant would have caused our findings.

Possibly the combustion products of coal gas and natural gas differ in some relevant way. We could not separate the effects of the two types of gas because most of the study areas underwent a changeover from town to natural gas during 1973, and the children were exposed to the products of combustion of both gases.

The relation between gas cooking and respiratory disease seems to be stronger and more consistent for girls than for boys, as would be expected if girls spent more time in the family kitchen. If this is the case, and the difference between the sexes is purely the result of differing exposure, it seems likely that increased ventilation might be sufficient to dispel any risk.

Nevertheless, detailed research is required to determine whether the relation we have found is really due to a direct effect of the products of gas combustion on the respiratory tract before more complicated measures for the protection of health are considered.

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Dextrostix-Eyetone in the insulin hypoglycaemia test

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Summary

The Ames Dextrostix-Eyetone system was evaluated for monitoring the blood glucose concentration during insulin-induced hypoglycaemia. The results agreed well with laboratory values for plasma glucose, obtained by an orthotoluidine method, and the method was practicable as a bedside technique. In two cases quick results obtained with the Eyetone enabled the insulin tolerance test to be interrupted to prevent severe hypoglycaemia before the clinical indications were obvious. The extra time and effort required were minimal, and its value seems to far outweigh the disadvantage of the extra work entailed. Nevertheless, care in using the system was important, and the operator must familiarise himself with the system before the most reliable results can be obtained.

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Introduction

The best validated test of pituitary growth hormone (GH) release in man is the insulin tolerance test (ITT), which allows GH and ACTH production by the pituitary to be assessed simultaneously.[1] The test is especially useful as thyrotrophin-releasing hormone (TRH) and gonadotrophin-releasing hormone (GRH) may be given at the same time so that prolactin and gonadotrophin secretion can be assessed simultaneously.

Adequate hypoglycaemia must be achieved before the ITT can be considered to be satisfactorily completed. Hypoglycaemia is generally recognised from the clinical signs (such as sweating) and, retrospectively, by seeing that the plasma glucose concentration has fallen by at least 50% from the fasting value and is below 2·8 mmol/l (50 mg/100 ml) at the nadir.[2] Because of this and of the danger of severe hypoglycaemia, especially in young children, there have been extensive searches for other

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